Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Use of Spectrum Bands Above 24 GHz For Mobile Radio Services	)	GN Docket No. 14-177
	)	
Establishing a More Flexible Framework to Facilitate Satellite Operations in the 27.5-28.35 GHz and 37.5-40 GHz Bands	)	IB Docket No. 15-256
	)	
Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service Rules for the 42-43.5 GHz Band	)	RM-11664
	)	
Amendment of Parts 1, 22, 24, 27, 74, 80, 90, 95, and 101 To Establish Uniform License Renewal, Discontinuance of Operation, and Geographic Partitioning and Spectrum Disaggregation Rules and Policies for Certain Wireless Radio Services	)	WT Docket No. 10-112
	)	
Allocation and Designation of Spectrum for Fixed-Satellite Services in the 37.5-38.5 GHz, 40.5-41.5 GHz and 48.2-50.2 GHz Frequency Bands; Allocation of Spectrum to Upgrade Fixed and Mobile Allocations in the 40.5-42.5 GHz Frequency Band; Allocation of Spectrum in the 46.9-47.0 GHz Frequency Band for Wireless Services; and Allocation of Spectrum in the 37.0-38.0 GHz and 40.0-40.5 GHz for Government Operations	)	IB Docket No. 97-95

COMMENT OF INTEL CORPORATION

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I. Introduction and summary

Intel Corporation ("Intel") respectfully submits this comment in the Commission's proceeding on the use of spectrum bands above 24 GHz for mobile radio services. Intel is a leader in designing and building the essential technologies that serve as the foundation for the world's computing and communications devices. We strongly back the Commission's efforts to make millimeter wave spectrum available for terrestrial mobile (5G) use expeditiously and flexibly.

The millimeter wave (mmW) spectrum bands proposed by the Commission in this NPRM[1] present a tremendous opportunity for future applications and services because of certain attributes unique to this spectrum. Compared to spectrum currently available for mobile cellular networks below 3 GHz, very large channels are possible (perhaps 100 times larger, or more). In turn, extremely high throughputs (multiple Gbps) are achievable.

The physics of these high frequencies in the 28-71 gigahertz range lead to much lower propagation and penetration characteristics, compared to lower frequencies. This could present limitations for the types of wide-area, longer-range applications and services provided in spectrum below 3 GHz,[2] but they are less problematic for many short-range applications and services commonly envisioned for the mmW bands. In addition, recent developments in very large antenna arrays at higher frequencies have enabled techniques supporting longer range and/or focused beams, in support of applications such as fronthaul/backhaul. Therefore the envisioned mmW usage models and

[1] *Use of Spectrum Band Above 24 GHz For Mobile Radio Services*, *et. al*., Notice of Proposed Rulemaking, GN Docket No. 14-177, Released Oct 23, 2015 ("mmW NPRM")

[2] Intel encourages the Commission to continue looking for more spectrum in the lower frequency bands to extend the value of well-established macrocell deployments.

technological developments can contribute to substantially limiting interference, and localized deployments can co-exist with less geographic separation due to the containment of signal energy.

The potential for new mobile applications and services in the mmW bands is very high, with a wide range of options in development, deployment, and adoption that will ultimately be sorted out by the market. In light of this, Intel recommends that the Commission take a highly flexible and investment-friendly approach in setting the mmW band rules. Such an approach is necessary to eliminate unnecessary risk and uncertainty in the technical and economic aspects of market development, and to encourage investment, discovery, risk-taking, and innovative solutions unencumbered by artificial or unintended limitations.

While equipment designers need specific numeric rules for designing equipment, other rules related to, *e.g.,* license term, license size, performance and build-out requirements, spectrum screens, and aggregation limits are ideally set based on realistic assessment of market development considerations. Those factors are not well-defined at present, and Intel believes the associated rules should accommodate that uncertainty where feasible and facilitate multiple competing business approaches.

Accordingly, Intel supports exclusive licensing for the 28, 37, and 39 GHz bands, and unlicensed Part 15 operations for the 64-71 GHz band. To the extent possible, common, band-neutral technical requirements will facilitate expeditious resolution of this NPRM, as well as aiding equipment development and deployment. We agree that the Commission should grant mobile licenses to terrestrial incumbents with full flexibility including secondary market transactions, partitioning, and disaggregation. Licenses should have a 10-year license term with renewal expectancy, and performance requirements should have the flexibility to accommodate a wide range of services. Unassigned licenses should be auctioned, and the geographic areas should maintain consistency with current licenses (BTA

for 28 GHz, EA for 39 GHz, and EA for 37 GHz as an extension of 39 GHz). Intel does not support the overlay licensing alternative for 28 and 39 GHz, or the hybrid plan for 37 GHz.

II. The 28 and 39 GHz bands should be flexibly licensed for mobile use and incumbents should be granted mobile authority.

A. Recommendations specific to the 28 GHz band

1. The 28 GHz Band Has Great Potential for Launching a Global Market in Millimeter Wave 5G Services.

Intel supports the NPRM's inclusion of the 27.5-28.35 GHz band (the 28 GHz band) for future mobile services. With 850 MHz of bandwidth, the 28 GHz band has great potential for bringing new 5G services to the marketplace. The 28 GHz band—more so than other mmW bands—has been the focus of academic research into channel models, and industry prototyping efforts. It is already designated as a primary mobile allocation in all regions worldwide. Korea and Japan have indicated they intend to use the band for the Seoul and Tokyo Olympics, to showcase 5G. Thus, the Commission's efforts toward the 28 GHz band in this NPRM are important for laying the groundwork to create a global market for millimeter wave 5G services.

Coexistence considerations in the band are relatively modest, with co-primary fixed terrestrial incumbents and a small number of secondary FSS uplink facilities (21, with 17 pending applications[3]) as the main incumbent occupants. Intel fully supports the Commission's proposal to grant flexible mobile licenses to the fixed terrestrial incumbents. Indeed, this is the most streamlined and expeditious means for completing this rulemaking and for bringing the 28 GHz band to market for mobile services.

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[3] mmW NPRM ¶136

2. Retaining 28 GHz Rules and Licensing Structures Compatible with Incumbent Licensees Is the Most Efficient and Expeditious Path Forward.

Intel supports the Commission proposal to maintain the 850 MHz license size. These licenses should be permitted to be channelized as licensees see fit, and in accordance with secondary market rules on disaggregation and partitioning, which Intel also supports for mobile services in this band. Unassigned 850 MHz licenses should be auctioned, using the same BTA license geographic areas as issued licenses. This minimizes compatibility and boundary issues with fixed licenses.

Intel does not support the NPRM's alternative proposal to use overlay license auctions. We believe the primary Commission proposal of a direct grant of mobile rights is consistent with past Commission decisions to convey both fixed and mobile rights to license holders in order to provide them with maximum flexibility in designing their systems, and is supported by the comment record in the NOI. The overlay auction approach would also present more challenging interference coordination between different co-channel entities, whereas a grant of mobile rights to the holder of fixed terrestrial rights would internalize that process, resulting in more manageable, efficient, and self-coordinated licenses. It is thus more conducive to swifter deployment than the overlay approach.

Certain other rules can be made common across the licensed bands and are discussed in a later section discussing common rules. To summarize these recommendations for the 28 GHz band, Intel supports many of the Commission's proposals, including market-oriented flexible duplexing rules; secondary market transactions including leasing, disaggregation, and partitioning; reasonable performance requirements tailored to the wide range of potential service offerings; 10-year license term with renewal expectancy.

3. A Market-based Mechanism to Address FSS Status Is Reasonable.

The NPRM considers how to facilitate satellite use of the 27.5-28.35 GHz band. Currently, the LMDS service is primary and FSS earth stations are secondary. The Commission proposes "a mechanism under which satellite earth stations could acquire co-primary status where their owners believe that such a level of protection is necessary."[4] The Commission correctly concludes that automatically granting FSS operations co-primary status would undercut the development of a terrestrial mobile service in this band.[5] Instead, the Commission proposes to enable FSS operators to achieve *de facto* co-primary status for their earth stations by acquiring terrestrial licenses by "participating in Commission auctions or by purchasing them from existing Upper Microwave Flexible Use licensees."[6] By acquiring the terrestrial license (or a partition thereof) wherein the earth station is located, the FSS licensee would have the "right to exclude other users from the geographic area of the license."[7] As the Commission concludes, this proposal has the virtue of establishing a "market-based mechanism for determining the highest and best use of the spectrum in a given area."[8] It would also allow sharing or partitioning between FSS and the terrestrial mobile service based on negotiation between the affected parties. This approach would be more flexible and efficient than the "top-down" regulatory alternatives.

The Commission also correctly concludes that this process would not be contrary to Section 647 of the Open-market Reorganization for the Betterment of International Telecommunications Act[9] which states that "the Commission shall not have the authority to assign by competitive bidding orbital

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[4] mmW NPRM ¶129
[5] mmW NPRM ¶130
[6] mmW NPRM ¶132
[7] mmW NPRM ¶132
[8] mmW NPRM ¶133
[9] mmW NPRM ¶134

locations or spectrum used for the provision of [international or global satellite] services."[10] Nor in this particular case are there potential "spillover" effects that have led some in the FSS community to question the utility of auctions with regard to satellite services.[11] Importantly, much of the world currently has allocated this band to FSS use. Thus, FSS operators in the U.S. would be positioned to capture the spillover effects from globally harmonized use at 28 GHz and therefore would not be at any disadvantage in bidding for or acquiring these terrestrial licenses.

The NPRM also considers the case where the FSS earth station licensee is located outside of the license area of an active LMDS license.[12] It seeks comment on whether such an earth station operator should have the opportunity to apply for a license during a filing window *restricted to the FSS operator thereby avoiding mutual exclusivity.* This approach directly conflicts with the market based approach the Commission proposes above and provides no assurance that the spectrum would be put to its highest and best use. No reason is offered why this extraordinary approach is warranted in this case.

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[10] 47 U.S.C. § 765(f)

[11] Letter from Satellite Industry Association to Senate Commerce Committee Chairman John McCain, dated November 11, 2003. In relevant part it states:

> Congress also recognized that the complex and time consuming process of deploying viable international satellite systems requires operators to secure rights in many countries rather than just one license in the United States. Section 647 was premised upon the understanding that if the United States were to employ auctions to grant licenses for international satellite services, other countries would inevitably follow suit. The result would be a cascading series of sequential auctions, which would be disruptive to the already lengthy planning process for the development of satellite networks, and would have a potentially devastating effect upon the delivery of, and access to, global satellite services. Sequential auctions in dozens of countries would not only add greatly to the upfront costs, but would create a staggering level of regulatory and business uncertainty. *Faced with multiple consecutive auctions, satellite operators would have no idea whether they would be able to win a sufficient number of licenses in an adequate number of countries to piece together a coverage area that would justify the costs of constructing networks.* Furthermore, the investment community would have no way of determining in advance the ultimate financial commitment. (emphasis added)

[12] mmW NPRM ¶139

The NPRM also seeks comment on whether the 28 GHz band should be opened to allow deployment of FSS fixed user equipment on a secondary basis, subject to the condition that the user equipment not cause interference to fixed or mobile operations.[13] The Commission seeks comment on several possible ideas for facilitating the deployment of FSS user equipment.[14] Again, none of these ideas is superior to the market-based approach the Commission already has proffered. The Commission asks "should we allow private agreements to supplement or replace any regulatory mechanisms we might establish to facilitate sharing? Could private agreements render rules unnecessary in this area?" The answers are "yes" and "yes." No market failure is posited and no reason is given as to why voluntary negotiations would not achieve an efficient result including the possibility that the affected parties might rely on any of the technical approaches on which the Commission seeks comment.

B. Recommendations specific to the 39 GHz band

1. Retaining 39 GHz Rules and Licensing Structures Compatible with Incumbent Licensees Is the Most Efficient and Expeditious Path Forward.

Intel believes the 38.6-40.0 GHz band (the 39 GHz band) holds great potential for offering a variety of innovative 5G services, especially when combined with the directly adjacent 37 GHz band as an exclusively licensed band. Up to 1400 MHz of spectrum could be available in the 39 GHz band,[15] subject to the future compatibility analysis and clarification of inter-service interference requirements with federal military satellite systems in the upper 500 MHz of the band.[16] Intel agrees with the Commission that the fixed incumbent licensees in the 39 GHz band should be granted the authority to

[13] mmW NPRM ¶147
[14] mmW NPRM ¶¶150-159
[15] When combined with the 37 GHz band, up to 3 GHz would be available.
[16] mmW NPRM ¶¶ 37, 46

provide mobile services.[17] For similar reasons as described in the 28 GHz section above, Intel does not support the alternative proposal for overlay licenses. A direct grant of flexibility to provide both mobile and fixed operations is consistent with past Commission decisions, alleviates coordination and interference concerns compared to fixed and mobile services provided by different co-channel entities, and has been the implied outcome by the Commission dating back many years.[18]

The Commission asks for comment on alternatives to the county-based licensing scheme it proposes.[19] Intel believes the current EA license scheme in the 39 GHz band would be better suited to this band than partitioning into over 3000 county-based licenses. We also believe this decision should be considered along with the partitioning and disaggregation rules, which increase the flexibility of EA licenses. This combination of EAs and the secondary market rules permitting disaggregation and partitioning (including the option to split paired licenses into unpaired) provide a better means of balancing the trade-offs between the Commission's many license size considerations. Further, maintaining service-area commonality with fixed terrestrial incumbent licensees should expedite the rulemaking. Intel notes that current Commission rules permit disaggregation, but only of paired channels ("licensees may…disaggregate any portion of spectrum, provided acquired spectrum is disaggregated according to frequency pairs."[20]) Intel recommends expanding disaggregation to include

[17] mmW NPRM ¶42

[18] *In the Matter of Amendment of the Commission's Rules Regarding the 37.0-38.6 GHz and 38.6-40.0 GHz Bands; Implementation of Section 309(j) of the Communications Act Competitive Bidding, 37.0-38.6 GHz and 38.6-40.0 GHz*, Report and Order and Second Notice of Proposed Rulemaking, ET Docket No. 95-183, released Nov 3, 1997, at 3 ("39 GHz licensees will be able to offer a variety of services including point-to-point, point-to-multipoint, and mobile operations (with implementation of mobile operations occurring after the Commission completes a rulemaking proceeding…)")

[19] mmW NPRM ¶113

[20] 47 C.F.R. § 101.56(a)(1)

the option of splitting paired channels, since this has the potential to make for more efficient channel organization.

In a prior Order where it selected EAs for 39 GHz fixed terrestrial licenses, the Commission notes,

> "We believe that licensing the 39 GHz band by EAs will provide ample population coverage and allow licensees the flexibility to provide many different types of services, which will promote an equitable distribution of licenses and services among geographic areas, encourage economic opportunities among a wide variety of applicants, and foster investment in and rapid deployment of new technologies and services. For entities desiring service areas smaller than EAs, we note that we are permitting partitioning and disaggregation in the 39 GHz band. The availability of these options will enhance 39 GHz licensees' flexibility regarding system design and service offerings, which will promote the efficient and diverse use of the 39 GHz band."[21]

These same arguments hold today. Regarding the benefit from allowing partitioning and disaggregation, the Commission notes in a prior Order,

> "We believe that the availability of [partitioning and disaggregation] options will enhance 39 GHz licensees' flexibility with respect to system design and service offerings. We also believe that partitioning and disaggregation opportunities further the objectives of Section 309(j) of the Communications Act by facilitating the development of niche markets and the arrival of new entrants, including small businesses, rural telephone companies and businesses owned by members of minority groups and women. In addition, these tools will promote efficient use of 39 GHz spectrum."[22]

Again, these same arguments hold today. However, in the NPRM, the Commission posits arguments against the use of larger license sizes such as EAs, some of which rely on presumptions that

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[21] *In the Matter of Amendment of the Commission's Rules Regarding the 37.0-38.6 GHz and 38.6-40.0 GHz Bands; Implementation of Section 309(j) of the Communications Act Competitive Bidding, 37.0-38.6 GHz and 38.6-40.0 GHz Bands*, ET Docket No. 95-183, Memorandum Opinion and Order, Released July 29, 1999, at 46 and footnote 179.

[22] *In the Matter of Amendment of the Commission's Rules Regarding the 37.0-38.6 GHz and 38.6-40.0 GHz Bands; Implementation of Section 309(j) of the Communications Act Competitive Bidding, 37.0-38.6 GHz and 38.6-40.0 GHz Bands*, Report and Order and Second Notice of Proposed Rulemaking, ET Docket No. 95-183, Released November 3, 1997, at 71.

services in the 39 GHz band will be predominately short-range and local in nature.[23] These points misconstrue the implications of the limited propagation of mmW signals. While some usage cases may be limited to sparse coverage areas, there are other 5G usage cases where geographically broad, blanket coverage or point-to-point backhaul links are the objective, and for which geographically large licenses are better suited. It is more efficient from both an operational and transaction cost perspective to deploy a blanket of small diameter cells into larger geographic licenses than to have the added complexity of trying to accomplish that objective while dealing with multiple boundary, interference, and transaction cost considerations associated with small geographic license sizes.

It is also quite plausible that, over time, service scope could expand from initially-localized services with limited adoption to wide-area services with broad adoption. Indeed, adoption of new and innovative services often follows a common path of sparse initial take-rate by early adopters before becoming a mainstream service. Hence, the Commission should not consider the signal propagation limitations as a key factor in the license size selection process, since it places an undue bias toward small geographic license size and services with limited and sparse scope.

Certain other rules can be made common across the licensed bands and are discussed in a later section discussing common rules. To summarize these recommendations for the 39 GHz band, Intel supports many of the Commission's proposals, including market-oriented flexible duplexing rules; secondary market transactions including leasing, disaggregation, and partitioning; reasonable performance requirements tailored to the wide range of potential service offerings; 10-year license term with renewal expectancy.

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[23] mmW NPRM ¶111

2. The Commission Should Consider a Separate Partition to Segregate the Future Federal/Military Use of 39.5-40.0 GHz from the Remainder of the Band.

The Commission notes that federal/military systems from the Department of Defense and NASA have stated potential future use of the 39.5-40.0 GHz segment, and that a future, separate proceeding would address potential interference issues.[24] In light of that cautionary note and the uncertain outcome of the future proceeding, it would be prudent to consider segregating the potential interference risk by making the 39.5-40.0 GHz range a separate partition within the 39 GHz band.

As we note below, we believe the determination of the best-suited channelization for a future 39 GHz auction of unassigned licenses would be clearer once a (proposed) voluntary repacking of the 39 GHz incumbents has completed. Incumbent licensees (which include 870 EA and 229 RSA licenses) currently cover an estimated 49% of the U.S. population, and that includes a number of licenses within the 39.5-40.0 GHz segment.[25] The question of whether sub-dividing the 39.5-40.0 segment is appropriate would likely be better addressed after a voluntary repacking has completed. For example, after the voluntary repacking,[26] remaining licenses in the 39.5-40.0 range may be clustered within a fixed frequency subset of that range (the lower 200 MHz as a hypothetical example), and it may be efficient to group those together to make the future auction more efficient.

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[24] mmW NPRM ¶¶37, 46

[25] Of the fourteen paired licenses in the 38.6-40.0 GHz range, denoted by sequential license pairs A-N, only four pairs (the A through D license pairs) do not have the upper 50 MHz of their pair in the 39.5-40.0 GHz range. According to a ULS lookup on 1-15-16, this corresponds to 296 active licenses, compared to 870 for the full range.

[26] Under a fungible license assumption (which could in theory include pair-splitting) and if the unassigned licenses held by the Commission are included in the repacking, more extensive repacking/swapping is possible.

3. The Current Paired 39 GHz Channel Assignments Do Not Pose a Barrier to a Flexible Duplexing Regime if the Commission Employs the Full Panoply of License Conversion Tools to Enable an Efficient Market-driven Determination of the Duplexing Scheme.

The Commission asks[27] whether the current channel plan, which favors FDD, could have an impact on permitting duplex flexibility in the 39 GHz band. Subject to enabling a full toolkit of license conversion options noted below, we do not believe the existence of a 39 GHz channel plan that currently favors FDD for fixed terrestrial deployments will be a barrier to duplexing flexibility for mobile operations. As long as licenses can be flexibly partitioned, aggregated, disaggregated (including pair-splitting), swapped, and voluntarily repacked, both TDD and FDD duplexing could be optimized by market participants. Some 39 GHz incumbents have indicated interest in a pre-auction voluntary repacking of the 39 GHz band so that their licenses are more conducive to TDD operations and/or larger contiguous blocks, and Intel would support such a voluntary effort. Even if some incumbents choose not to participate in repacking, there is still value in allowing willing incumbents to elect partial repacking of the band.[28]

When the rules for auctioning the unassigned 39 GHz spectrum are developed, the status of this voluntary repacking process would be a key input in deciding whether auctioning paired, unpaired, or a combination of both license types, is most efficient. Post-auction license swaps and aggregation/disaggregation should also be permitted, since it could produce a more efficient outcome, *e.g.*, if auction results were less than ideal for several license winners, or to better suit evolving technologies and service needs in the future. Under our recommendation for the 37 GHz band to be

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[27] mmW NPRM ¶270

[28] If the Commission as well as incumbent licensees are satisfied that 39 GHz licenses can be partitioned into a small number of groups of substantially equivalent licenses, *i.e.*, the licenses within that group are *fungible*, mutually beneficial swaps may be possible, and would promote the larger public interest.

exclusively licensed using rules common to the 39 GHz band, the decision on auctioning paired or unpaired licenses in the 39 GHz would in theory be replicated in the 37 GHz band. However, Intel would potentially support a different license partitioning in the 37 GHz band versus the 39 GHz band, if that proves to be more efficient and comports with market consensus. Since the 37 GHz band does not have commercial incumbent licensees or other constraints present in the 39 GHz band, a different license size partitioning may be efficient.

III. The 37 GHz band should be exclusively licensed for mobile use, rather than the proposed hybrid sharing plan.

A. The market demand and requirements for the Commission's proposed enterprise/industrial user class could presumptively be met, perhaps better met, by other bands.

In the NPRM, the Commission justifies the creation of a hybrid model for 37 GHz by stating there is a neglected user group of private enterprise and industrial users who are not adequately served by either of the two prevalent models (*i.e.*, the unlicensed model of user-deployed Wi-Fi, and the service provider model).[29] The Commission proposes a license-by-rule classification to meet this neglected need.

There is an insufficient basis for believing that assigning this 1.4 GHz block of spectrum in this novel way, and to this ill-defined new user class, would be the optimal use of one of the largest blocks of unencumbered spectrum in history. First, the market size and growth potential of this enterprise/industrial self-deployed user category has not been quantified. Second, interested members

[29] mmW NPRM ¶100

of this user class have not defined the types of applications, bandwidth, range, and other utilization requirements. Third, there is a lack of demonstrated vendor backing for developing the ecosystem of supporting products, services, and standards for this user class. Fourth, there is no proven, scalable sharing framework to accommodate even a subset of the myriad attributes discussed in the NPRM, implying a lengthy development and trial process, and assuming all the other market viability issues are first satisfied. Fifth, the appropriateness of this band compared to other options, in consideration of all the above factors, has not been shown. Thus, there is an inadequate and incomplete basis for concluding that such a model would be viable let alone optimally situated in 1.4 GHz of spectrum in the mmW bands. Indeed, there is reason to believe that the requirements of such a user class could be met, perhaps better met, by other spectrum bands, as described below.

An especially important and unquantified question for this large 1.4 GHz allocation is whether this enterprise/industrial user class might value the license-by-rule classification above all else, and their bandwidth needs are actually quite modest. One could imagine at least some portion of this user class might consist of, for example, industrial process control and factory automation. Such applications could be served with considerably less bandwidth. The amount of bandwidth available in current unlicensed bands could be sufficient, were it not for the users' need for stronger protection rights than an unlicensed Part 15 network provides (which is stated as a primary distinguishing attribute for this user class). Hence, the Commission proposes license-by-rule to serve the needs of this user class.

Should those circumstances of more modest bandwidth needs better represent this enterprise/industrial user class, Intel would suggest that the recently allocated spectrum in the 3.5 GHz band could be well-suited. It not only already has a license-by-rule user class, but also has geographically-small exclusive licenses which would approximate the size of such enterprise/industrial facilities. Small exclusive licenses might be even more attractive than license-by-rule for certain

members of this user class. Furthermore, the development of the sharing framework at 3.5 GHz is well underway (and in any case, that framework has unproven scalability to other bands, 37 GHz in particular).

Additional alternative locations, in the 57-71 GHz band, could be investigated (subject to interference impact and coexistence assessments in a future rulemaking). If the bandwidth needs of this user class prove to be fairly modest, the 50 MHz coordination channel associated with the 57-64 GHz band could be used, under a license-by-rule classification. In a later section, Intel discusses our support for the Commission's efforts in this NPRM to remove the current exclusion of the 57.00-57.05 GHz coordination band segment, in order to "provide an extra 50 MHz of spectrum for data transmission."[30] Still another alternative location—if certain members of this user class seek to use mmW frequencies—would be at the top of the 64-71 GHz band. In a later section, Intel recommends that the 64-71 GHz band should be allocated for unlicensed Part 15 use, as an adjunct to the existing 57-64 GHz band, and discusses how this fills the need for six contiguous WiGig channels at 2.16 GHz each, extending from 57.24-70.20 GHz. This potentially leaves 800 MHz of remainder (down from 71 GHz), and some portion of that remainder could serve the license-by-rule needs of certain members of this user class.

To summarize, the only key attribute the Commission has defined for this new user class is the license-by-rule classification. The potential market size and growth of the proposed user class is unquantified; bandwidth and other user requirements are undefined; the necessary interest from the vendor ecosystem to develop products, services, and standards has not been demonstrated; there is no proven, scalable sharing framework; other bands may be more ideally suited, once the aforementioned issues are better defined.

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[30] mmW NPRM ¶312

B. With its absence of incumbent licensees and its adjacency to the 39 GHz band, the 37 GHz band is ideally suited to exclusive licensed new entrants.

As described above, Intel does not support the hybrid sharing plan for 37 GHz, and instead recommends that the band should be exclusively licensed, with the service rules aligned with the 39 GHz band to the extent practical, including secondary market leasing, partitioning, and disaggregation. This commonality will increase the efficiency of product development and deployment across exclusively licensed bands.

Its adjacency to the exclusive licensed 39 GHz band further increases its attractiveness to the mobile industry, and would expedite this rulemaking and service introduction. Thus, Intel supports exclusive licensing for the 37 GHz band, and has suggested several alternative spectrum bands which are perhaps more suitable for the currently ill-defined enterprise/industrial user class.

Certain other rules can be made common across the licensed bands and are discussed in a later section discussing common rules. To summarize these recommendations for the 37 GHz band, Intel supports many of the Commission's proposals, including market-oriented flexible duplexing rules; secondary market transactions including leasing, disaggregation, and partitioning; reasonable performance requirements tailored to the wide range of potential service offerings; 10-year license term with renewal expectancy.

IV. The 64-71 GHz band should be unlicensed, as an extension of the 57-64 GHz band, under Part 15 rules.

A. Strong industry support for products and standards development in the adjacent 57-64 GHz band will carry over to the extended allocation from 64-71 GHz, upon Commission action.

Intel agrees with the Commission's proposal to allow unlicensed operations in the 64-71 GHz band under the same rules as the adjacent 57-64 GHz band.[31] As the Commission notes, "Commenters unanimously support this action and recommend that the Commission proceed with extending the band to cover 57 to 71 GHz under the same Part 15 provisions that allow operation in the currently authorized 57-64 GHz band."[32]

The 64-71 GHz band is ideally situated to extend the growing demand for high capacity wireless LAN applications. Industry stakeholders have shown strong support for IEEE 802.11ad (WiGig®) products. The demand has been growing so rapidly that recently the IEEE 802 has created a new 802.11ay project to extend 802.11ad, which would also include the directly adjacent 57-64 GHz band. So far, nine usage models have been defined for IEEE 802.11ay[33] As the IEEE Project Authorization Request (PAR) for 802.11ay explains, "wireless LAN usage continues to grow and find new applications demanding additional capacity. As an example, the speed of wired interfaces such as Ethernet, HDMI, USB and DisplayPort can far exceed 10 gigabits per second. This is in addition to other usages such as cellular offload, wireless docking, wireless display and backhaul. Therefore, there is a need to

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[31] mmW NPRM ¶300
[32] mmW NPRM ¶302
[33] IEEE usage models document can be downloaded from:https://mentor.ieee.org/802.11/dcn/15/11-15-0625-03-00ay-ieee-802-11-tgay-usage-scenarios.pptx

substantially increase the achievable throughput of IEEE 802.11 devices and the overall capacity of IEEE 802.11 deployments."[34]

The envisioned applications and usages identified by the IEEE task group 802.11ay require additional spectrum. The growing list of both indoor and outdoor applications calls for much higher throughputs (20 Gbps and higher) than are currently attainable in the 57-64 GHz band alone. Such data rates are derived by employing novel techniques such as channel bonding and MIMO.

The IEEE PAR calls for a *minimum* throughput capability of 20 Gbps, measured at the MAC level. For this minimum requirement to be met, the physical layer rate should be approximately 30 Gbps, assuming typical efficiencies of wireless LAN protocols. When considering that practical physical layer rates supported by the current 802.11ad standard are less than 5 Gbps/channel, six channels are necessary to meet this requirement. At 2.16 GHz bandwidth per channel and six channels, the necessary bandwidth extends from 57.24-70.2 GHz.

A lesser amount of spectrum would diminish the growth potential and limit the usage cases and the simultaneous users of high bandwidth services. Note also, the reduced oxygen attenuation in the 64-71 GHz band compared to the 57-64 GHz band could translate into longer-range applications, making this spectrum more attractive for certain outdoor applications such as backhaul and fronthaul of future small cells operating in lower bands.

[34] IEEE PAR can be downloaded from: https://mentor.ieee.org/802.11/dcn/14/11-14-1151-08-ng60-ng60-proposed-par.docx

B. The Commission should permit operation aboard aircraft and should eliminate the coordination channel requirement.

Intel supports the Commission's consideration of lifting the prohibition on usage aboard aircraft in the existing allocation of 57-64 GHz, and refrain from introducing such a restriction in the proposed 64-71 GHz allocation. The Commission notes the ongoing effort between industry, NTIA, and other stakeholders "to study compatibility of operation of these new chipsets and their operation on-board in-flight aircraft."[35]

As the Commission further notes, there are difficulties in enforcing the current prohibition.[36] It essentially relies on user self-enforcement, since the devices have no way of knowing when they are on-board an aircraft, unless the user manually sets the device to airplane mode. The alternative proposal of potentially limiting the frequency range[37] does not seem advantageous and would also require self-enforcement, since any reduced frequency range would only be enabled when aboard aircraft, and that would be manually set by the user.

Regarding the "Publicly-Accessible Coordination Channel," Intel agrees with the Commission's proposal to eliminate the 50 MHz coordination channel requirement at 57.00-57.05 GHz, and agrees that coordination is better dealt with via voluntary standards than having a coordination channel set-aside in the rules. The bandwidth freed up by this action would "provide an extra 50 MHz of spectrum for data transmission" and is expected to be an unopposed action, given there have been no reports

[35] mmW NPRM ¶306
[36] mmW NPRM ¶304
[37] mmW NPRM ¶306

submitted relative to any activities in this band since the initiation of the requirement over a decade ago.[38]

V. Discussion of rule proposals common across licensed bands: the rules should accommodate the nascent millimeter-wave market development without undue restrictions and should maximize flexibility.

A. Flexible duplexing rules should be adopted for all millimeter wave bands.

Intel supports the Commission proposal for flexible duplexing in all bands. Both TDD and FDD (and any future duplexing scheme) should be permitted by the rules, and private parties should be permitted to decide on the most appropriate duplexing scheme at any point in the future, without the delays associated with a future regulatory proceeding to broaden or change the duplexing scope. While the current state of technology favors TDD for mobile operations, this may change with future technology developments, or due to future services. Again, this is a rule where the uncertainty in future operations calls for flexibility. We note that the 39 GHz band in particular (due to its existing band plan favoring FDD) has more duplexing considerations than other bands; these are discussed in the earlier section on 39 GHz band recommendations.

B. The "use-it-or-share-it" proposal is counterproductive to other Commission objectives in this proceeding.

Intel does not support the use-it-or-share-it requirement proposed in the NPRM, which would be imposed on licensees in the mmW bands, and take effect 5 years after license issuance.[39] In terms of the proposal itself, the definition and measurement of what constitutes "unused" is problematic and

[38] mmW NPRM ¶312
[39] mmW NPRM ¶216

dynamic. In a nascent market like mmW, it would be difficult to pre-judge fairness of those definitions since services are adopted at an unpredictable pace and geographic scope. It should also be noted that the other side of the transaction (i.e. what are the permitted conditions for the licensee to reclaim the spectrum from the sharing party, or, under what conditions or metrics has the sharing party failed to use the spectrum in a timely manner) must be defined, and is equally problematic. Further, the uncertain timing of when the licensee might reclaim the spectrum from the sharing party makes for an impractical and uncertain business case for the sharing party. Even for private use, the sharing party would have no guarantee of long-term use.

Also, implementation of the proposal could undermine other Commission objectives. Since the use-or-share requirements would necessitate a regulatory pre-judgment of what constitutes an inappropriate pace and geographic scope of deployment and adoption, it effectively becomes a second form of build-out and performance requirements. As such, the Commission would have to make a similar "degree of utilization" judgment, but at a different geographic scope and with different trigger points, compared to the performance requirement. This would be counterproductive to the intent of the build-out and performance requirements.

The solution is clear: a non-licensee party interested in using a partition of a licensee's spectrum should seek to lease the spectrum (or some other negotiated terms of use). Indeed, that is the scenario underpinning secondary market leasing, and as such, a use-it-or-share-it mandate undercuts the efficient operation of secondary markets. Stated differently, when the Commission authorizes secondary market transactions in a band of spectrum, the licensee directly faces the opportunity cost of keeping spectrum idle. Such is not the case with a use-or-share requirement. There is yet another solution for the non-licensee as well: if the non-licensee is not interested in leasing spectrum, they have an existing alternative to use unlicensed bands. Since there is currently 7 GHz, and presumptively an

additional 7 GHz of unlicensed spectrum soon available in the 57-71 GHz range, the non-licensee has that alternative, in addition to leasing. There is not only no problem solved by the use-or-share proposal, it creates problems by interfering with the efficient operation of other Commission objectives.

The Commission also seeks comment on the framework to enable the use-or-share proposal. This leads to an additional argument why a use-or-share requirement should not be considered in this NPRM. Such a framework would indeed be necessary, but developing such a framework would unnecessarily consume both industry and Commission resources for a considerable time, on something of questionable value and no demonstrated demand in the mmW bands—especially in light of the alternatives noted above. The Commission asks, "Would an SAS be the best means of administering a sharing mechanism."[40] Unless and until the sharing (SAS) concept proposed in the 3.5 GHz band is proven technically and operationally under a broad range of user and usage conditions, and also proven for scalability to other bands, it should be considered an unproven experimental concept.

The SAS concept—once proven in the 3.5 GHz band--could be useful in other bands, and it should not be re-invented from scratch with each band. However, scaling such a framework from a fully-proven concept in the 3.5 GHz band and all the idiosyncratic risks associated with that band, to another band and its different collection of risks and requirements, would not likely be a simple undertaking. For the purposes of this proceeding, developing such a framework would be an unnecessary burden layered onto all the more directly pertinent mmW efforts.

In summary, if the Commission wants secondary markets to work effectively, it should not layer in a use-or-share mandate, which undercuts them. Further, if the Commission wants any performance and build-out requirements it adopts in this proceeding to serve a productive and tractable purpose, it

[40] mmW NPRM ¶217

should not layer in a use-or-share mandate which is an additional form of such requirements but with a different geographic scope and with different trigger points. Finally, the sharing framework necessary for a use-or-share requirement specific to these bands is an unnecessary developmental burden, and is a superfluous effort in light of the aforementioned conflicts between the use-or-share proposal and established Commission objectives.

C. The Commission should adopt a 10-year license term with renewal expectancy and a flexible framework for performance requirements.

Intel suggests that license term, renewal expectancy, and performance requirements are best considered jointly, and should be set in such a way that they do not unnaturally interfere with the market decisions of licensees. A 10-year license term is reasonable in light of the uncertainties associated with the mmW market's development as discussed in earlier sections. Briefly, the license term should reasonably accommodate the development, deployment, and adoption of new, innovative services which have no current market history for judging the expected timelines. While there is no accurate formulaic means of determining the timeline, a 10-year license term seems reasonable under an expectation of showing significant progress toward the deployment of new services at the end of the 10 years. Linked to that, licensees should be given the certainty of renewal expectancy so long as they meet the performance requirements. With that backdrop of a 10-year license term and contingent renewal expectancy, performance requirements then have a time-bound, incentive-based target.

Intel appreciates the difficulty faced by the Commission in defining performance requirements to cover an unknown but broad range of new services in the mmW bands. The requirements should not discourage risk-taking in providing new services where customer awareness and adoption need time to be built from the ground-up. At the other end of the scale, some service deployments may be substantially similar to existing wide-area offerings in lower frequency bands and may be adopted

swiftly. Quantitatively, there is a large measurement gap between those equally legitimate service targets.

Performance requirements should not cause a licensee to alter its business plans in order to meet an ill-fitting requirement. In such a case, the requirements would not just be missing their target purpose, they could have a negative financial impact on the business and on the success of the mmW bands. However, a set of requirements which accommodates innovative new services cannot be specified so loosely that it "open[s] the possibility of gaming the performance requirements."[41]

In consideration of the above arguments, Intel does not believe the Commission's desire "to have a universal performance metric that could work across various types of services"[42] is realistically attainable. A "one size fits all" requirement would have inherent bias, in that meeting the requirement would be essentially automatic for some licensees, and nearly impossible for others, depending on the services they choose to provide.

Consequently, Intel proposes the Commission consider a performance requirement *framework* consisting of several elective categories, each flexibly defined, and each containing a safe harbor within its set of requirements. Licensees would choose the best-fit category for the services they are deploying, subject to Commission challenge, to avoid the gamesmanship issue. For example, one category would be "unit-based" (where a unit could be a count of e.g. people, devices, or sensors connected by the service), another category would be area based, and another would be usage based (e.g. busy-hour traffic carried or sessions established). Each of these categories has the ability to broadly demonstrate

[41] mmW NPRM ¶204
[42] mmW NPRM ¶204

spectrum is being put to a valued use for a given service type, and that is the goal. The Commission should not seek an artificial level of precision in these requirements. It is not currently attainable.

Given the current lack of substantive information on services, the prudent course of current action would be to define a framework for the requirements and set guide posts and expectations for future actions, and then revisit it in the future when better information is available. It is neither necessary nor possible to perfectly define these requirements out of the gate. The Commission could handle the future actions in various ways, including future direction to stakeholders to submit detailed proposals by a date-certain, and if stakeholders fail to produce such proposals by the date-certain, it will act.

D. Secondary market leasing, partitioning and disaggregation should be permitted in all licensed millimeter wave bands.

Intel supports permitting the full range of secondary market transactions, including leasing, partitioning and disaggregation, in the 28 GHz, 37 GHz and 39 GHz bands. Since the 39 GHz band has existing paired (2 x 50 MHz) licenses for fixed terrestrial use, which are relatively small and favor FDD deployment, the earlier section discussing specific recommendations for that band covers this topic in more detail. However, the benefits of a full toolkit of secondary market transactions are valuable to have in place for all licensed bands. Earlier sections also note that secondary market transactions are complementary to larger license size, contribute to effective flexible duplexing rules, and that such transactions (leasing in particular) are undercut by the use-it-or-share-it proposal which Intel opposes.

The Commission has previously noted the efficiency value of partitioning and disaggregation in these bands. For example, it notes that they "…further the objectives of Section 309(j) of the Communications Act by facilitating the development of niche markets and the arrival of new entrants,

including small businesses, rural telephone companies and businesses owned by members of minority groups and women."[43]

With respect to the 39 GHz band, Intel notes that under current Commission rules,[44] licensees are only permitted to disaggregate by (FDD) pairs. Intel believe there is value in expanding that rule to also permit pair-splitting, since TDD is the most likely mobile deployment technology, at least in the early market. This not only reinforces the proposed flexible duplexing rule, but also could permit more efficient channelization as well as more efficient voluntary repacking.

VI. Conclusions

Intel supports the Commission's efforts to make millimeter wave spectrum available for terrestrial mobile (5G) use expeditiously and flexibly. Specifically, we support exclusive licensing for the 28, 37, and 39 GHz bands, and unlicensed Part 15 operations for the 64-71 GHz band. Common, band-neutral technical requirements will facilitate expeditious resolution of this NPRM, as well as aiding equipment development and deployment. Terrestrial incumbents should be grated mobile licenses with full flexibility including secondary market leasing, partitioning, and disaggregation. Licenses should have a 10-year term with renewal expectancy, and performance requirements should have the flexibility to accommodate a wide range of services. Duplexing choice should be market-driven and remain flexible. Unassigned licenses should be auctioned, and the geographic areas should maintain consistency with current licenses (BTA for 28 GHz, EA for 39 GHz, and EA for 37 GHz as an extension of 39 GHz). Intel does

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[43] *In the Matter of Amendment of the Commission's Rules Regarding the 37.0-38.6 GHz and 38.6-40.0 GHz Bands; Implementation of Section 309(j) of the Communications Act Competitive Bidding, 37.0-38.6 GHz and 38.6-40.0 GHz*, Report and Order and Second Notice of Proposed Rulemaking, ET Docket No. 95-183, released Nov 3, 1997, at 71

[44] 47 U.S.C. § 101.56(a)(1)

not support the overlay licensing alternative for 28 and 39 GHz, the use-it-or-share-it proposal, or the hybrid plan for 37 GHz.